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13. ABSTRACT (Maximum 200 words)

Progress has been made on a number of problems including improved algorithms for the minimum cut problem and the arrangement problem as well as new data compression techniques for the shortest path problem.

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This report describes research carried out under Air Force Office of Scientific Research contract F49620-92-J-0116. I have also included papers supported through the contract.

The Assignment Problem. Yusin Lee and I have developed an approach that has solved n x n assignment problems with m arcs in O(m) time on average (using randomized instances.) This running time is remarkably fast. In addition, we can justify our O(m) running time using a mixture of empirical analysis and mathematics. This technique may be of great use in solving problems which use an assignment algorithm as a subroutine. For example, one could use this approach to solve problems with embedded assignment problems using lagrangian relaxation. This research led to two papers.

The Minimum Cut Problem. (Joint with J. Hao.) We show how to find the minimum cut in either a directed or undirected network by solving a sequence of n maximum flow problems whose cumulative running time is provably the same as the running time to solve a single maximum flow problem.

Lagrangian Relaxation. Dimitris Bertsimas and I show how to solve the lagrangian dual using ellipsoid-type methods. This approach (currently) yields the best worst case running times for a number of classes of lagrangian relaxation problems. Also, it may turn out to be one of the few applications where ellipsoid-type algorithms work well in practice.

Data Compression for Shortest Path Problems. In solving the all pairs shortest path problem, one typically stores solutions in terms of the n shortest path spanning trees. The space to store these trees is $O(n^2)$. One can do much better if one only lists differences between successive trees. In practice, one can improve the storage by a factor of nearly $\sqrt{n}$. Unfortunately, this data storage technique does not permit one to recover a single shortest path tree (or a shortest path from a source node to a sink node) efficiently. We show how to modify this approach so that each tree can be recovered in O(n) steps in the worst case, and each path with p arcs can be recovered in O(p) steps on average. Moreover, the storage required for this data compression technique is within a small constant of the best possible compression.

Simulated Annealing. Simulated annealing is a very appealing heuristic methodology because of its simplicity and robustness. Unfortunately it is computationally very intensive. We consider an approach that is known as rejectionless simulated annealing. We have implemented the problem on the maximum independent set problem. When implemented with efficient data structures, the running time per iteration is 100's of times faster than ordinary simulated annealing when the temperature is low. We believe that this approach would be very successful on a wide range of other problems as well.

Network Flow Book. Ravi Ahuja, Tom Magnanti and I have completed an 800 page text entitled *Network Flows: Theory, Algorithms and Applications*. It will be published in January, 1993 by Prentice Hall. Among its features are the following (as taken from the back cover of our book):

- Provides an integrative view of theory, algorithms and applications of network flow problems.
- Combines classical results since 1950's with recent state-of-art developments.
- Emphasis on recent algorithmic stategies and data structures.
- A readable, accessible, and insightful presentation and requires no background in optimization and computer science. Suited for readers with different backgrounds.
- An introductory as well as advanced text book on network flow problems.
- A comprehensive reference book for researchers and practitioners.
- Describes over 150 real world aplications of network flow problems in numerous problem domains.
- A rich collection of exercises with varied levels of difficulty.
- Includes extensive reference notes.